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The South American Geocentric Reference System and the Geodetic Network for the Americas

Paper submitted by the South American Geocentric Reference System**

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ABSTRACT

The South American Geocentric Reference System (*Sistema de Referência Geocêntrico para a América do Sul - SIRGAS*) project is presented, including its background, project goals, objectives, and structure. Since its establishment, in October 1993, the two working groups ("Reference System" and "Geocentric Datum") have carried out all of the tasks towards defining a new geocentric reference system and an associated datum for South America. The first project objectives were achieved on schedule in 1997 and the final report was presented at the International Association of Geodesy (IAG) Scientific Assembly, held in September 1997, in Rio de Janeiro. At the same meeting, the third working group ("Vertical Datum") was created with the objective of defining and establishing a unified vertical reference system for the continent. To accomplish this, the SIRGAS 2000 Global Positioning System (GPS) campaign was carried out from May 10 to 19, 2000. The 58 stations established during the first phase of the project were reoccupied (in order to support the computation of velocities for each station), as well as tide gauges used to classically define the national vertical networks in the past. In this campaign, the participation of North America, Central America, and Caribbean was coordinated, establishing a framework covering the whole Americas. With SIRGAS, the entire continent has an up-to-date and consistent framework, compatible with modern positioning techniques, according to the georeferencing requirements of the new millennium.

INTRODUCTION

The South American Geocentric Reference System - SIRGAS (*Sistema de Referência Geocêntrico para a América do Sul*) project was initiated at the International Conference for the Definition of a South American Geocentric Datum, convened from 4 through 7 October 1993, in Asuncion, Paraguay, by invitation of the International Association of Geodesy - IAG, the Pan-American Institute of Geography and History – PAIGH, and the United States Defense Mapping Agency - DMA (now, National Imagery and Mapping Agency - NIMA). Representatives of the

three sponsoring organizations and of almost all South American countries participated in that Conference.

The objectives established for the project were the following:

- to define a reference system for South America;
- to establish and maintain a reference network; and
- to define and establish a geocentric datum.

The goals to be achieved were:

- to reach the defined objectives in 1997, coinciding with the Scientific Assembly of the International Association of Geodesy, with the exception of maintenance which is permanent;
- to promote and coordinate the efforts of each South American country to achieve the defined objectives;
- to establish a high precision Global Positioning System (GPS) network, in accordance with the objectives of Resolution No. 2 of the 10th Meeting of the Directors of South American Geographic Institutes (DIGSA), held in La Paz, Bolivia, in 1993;
- to concentrate attention at the beginning on the Horizontal Datum; and
- to facilitate the connection of pre-existing networks.

The following definitions of the reference system and of the geocentric datum for the continent were adopted by the participants of the Asuncion Conference:

- SIRGAS reference system: IERS (International Earth Rotation Service) Terrestrial Reference Frame (ITRF) [http://lareg.ensg.ign.fr/ITRF/];
- geocentric datum: coordinate axes based on the SIRGAS reference system and parameters of the "Geodetic Reference System 1980 (GRS80)" ellipsoid [http://www.dgfi.badw.de/geodis/REFS/grs80.html].

The activities of the SIRGAS project have been designed to develop a continental reference network with a precision and accuracy compatible with modern positioning techniques, mainly those associated with GPS. Considering the proliferation of GPS utilization, it was decided that it would be, at the very least, a waste of resources to tie the new surveys to the existing geodetic structure which was based on classical survey methods (triangulation, traverse, trilateration, etc.) and for which the precision is at least ten times worse than that easily obtained with the GPS. In addition, the multiplicity of classical geodetic systems used by the South American countries made the solution of technically simple problems, such as the definition of international borders, very difficult. The adoption of the ITRF as a common reference system guarantees the

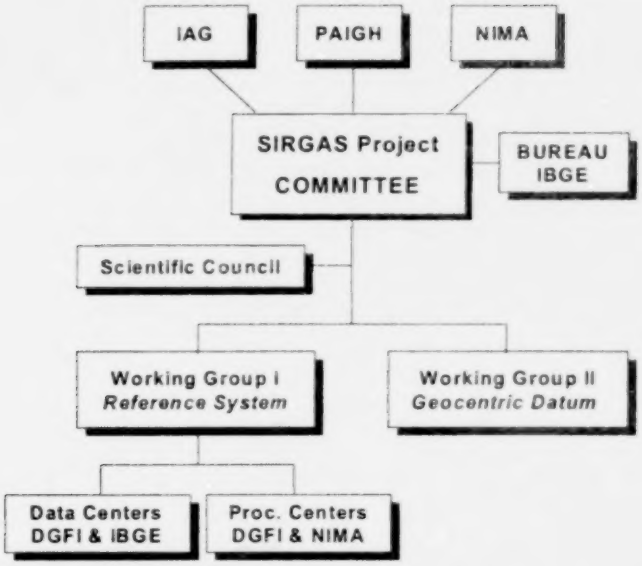

Figure 1: Organizational structure of the SIRGAS project, created during the Asuncion conference, in 1993

homogeneity of the results within the continent and allows the consistent integration of the SIRGAS network with the networks of other continents, thus contributing more and more to the development of a global geodesy.

WORKING GROUPS' ACTIVITIES

The organizational structure of the project, created during the Asuncion conference, is shown in Figure 1.

The project committee is composed of a representative from each country of the continent and one from each sponsoring organization. The committee is responsible for establishing the direction of the project and for analyzing the results obtained by the working groups. The bureau works as the committee headquarters, furnishing support to the president of the committee in accomplishing his tasks. The scientific council is composed of eminent professionals in geodesy from the international community, whose charge is to assist the committee and the working groups in their analyses and decisions.

The working group I (WG I) has been responsible for the establishment of the reference system. For this purpose, it organized a continental GPS campaign, carried out from May 26 to June 4, 1995. During this campaign, 58 principal stations and 9 eccentric ones were occupied (Figure 2), establishing one of the most accurate continental geodetic networks in the world. The accuracy of the station coordinates is estimated to be better than 2 cm. The processing of the GPS data collected during the campaign was accomplished independently by Deutsches Geodaetisches

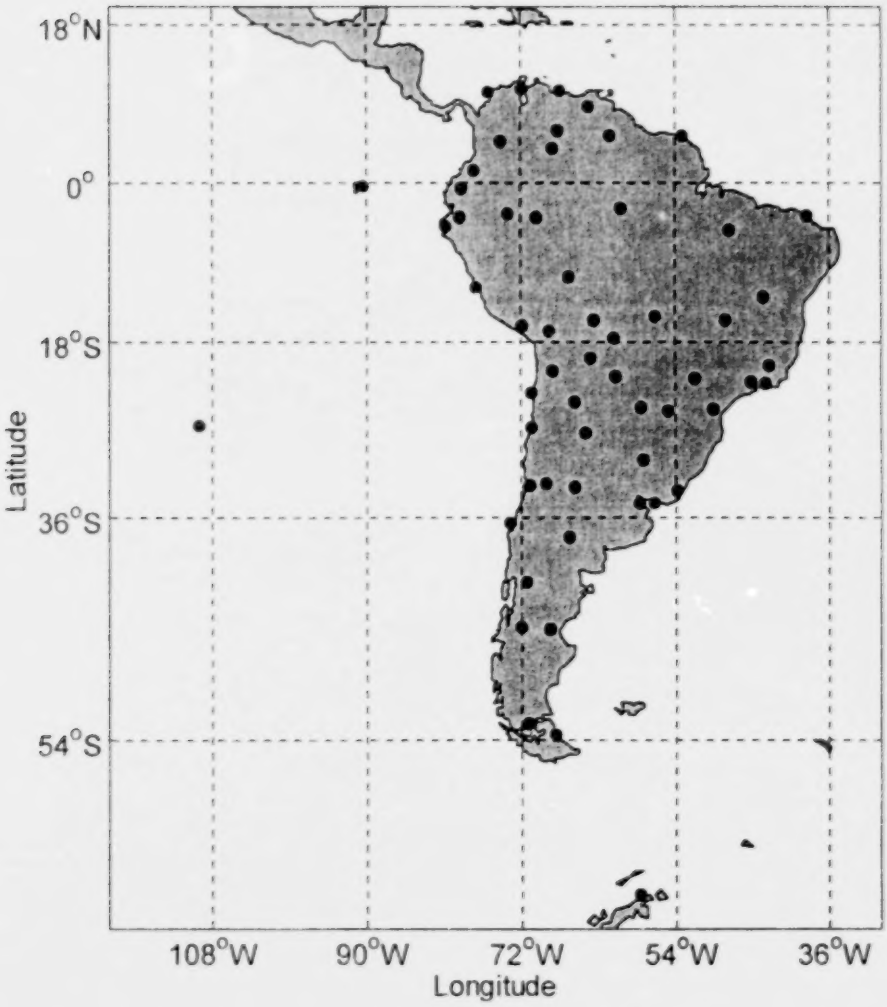

Figure 2: Principal stations occupied during the SIRGAS 95 GPS campaign (total of 58)

Forschungsinstitut (DGFI), Germany (as the IAG representative in the project) and by NIMA, USA.

Working group II "Geocentric Datum" (WG II) has been in charge of coordinating the integration of the national geodetic networks of each South American country into the SIRGAS reference frame. Each country, with support of WG II, has individually carried out such integration.

The official results for the continental reference network, as well as the status of the national geodetic networks' integration into SIRGAS, were presented during the IAG Scientific Assembly, held in September 1997, in Rio de Janeiro, as planned in the Asuncion conference. During the same event, the working group III "Vertical Datum" (WG III) was created, with the following objectives:

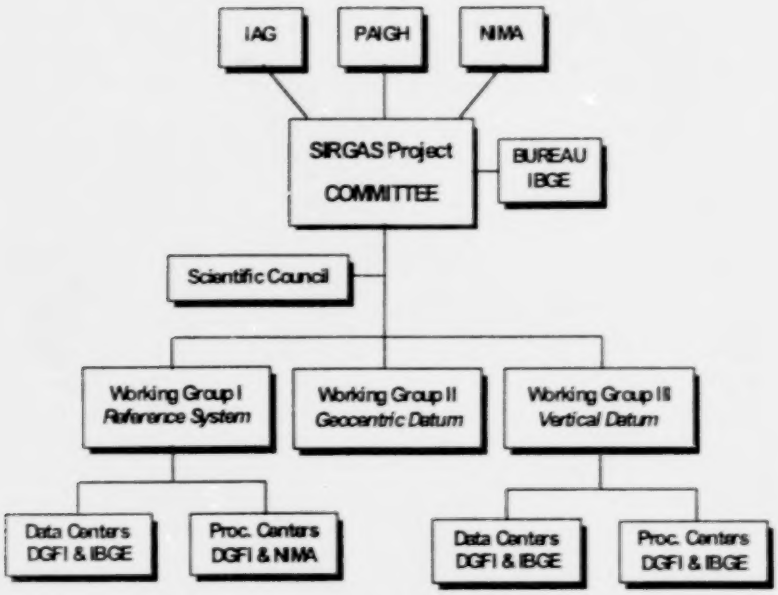

Figure 3: Organizational structure of the SIRGAS project, after establishing the WG III, during the Rio de Janeiro meeting, in 1997

- to define and establish a unified vertical reference system for the continent;
- to connect the existing altimetric networks to the new datum.

With the WG III created during the IAG meeting, the project structure changed to the one shown in Figure 3.

The working groups have organized the following meetings by the present date:

- April 20-22, 1994, Bogota, Colombia: first WG II meeting;
- October 24-28, 1994, La Plata, Argentina: first WG I meeting and second WG II one;
- August 5-9, 1996, Santiago, Chile: second WG I meeting and third WG II one;
- April 8-11, 1997, Margarita Island, Venezuela: third WG I meeting and fourth WG II one.
- August 11-13, 1998, Santiago, Chile: first WG III meeting;
- July 19-30, 1999, Birmingham, UK: fourth WG I meeting and second WG III one.

During the first WG III meeting, aspects related to the height system and the reference surface to be adopted in the continent were discussed, being decided that two types of heights will be adopted: ellipsoidal heights, referred to the SIRGAS datum, and another type based on geopotential numbers. In addition to that, it was decided to realize the vertical reference system through a set of stations with known SIRGAS coordinates, for which geodetic leveling and gravimetric information is available, and tide gauges that define the classical vertical datum in each country.

The SIRGAS 2000 GPS campaign was jointly planned by WG I and WG III and accomplished from May 10 to 19, 2000, with two objectives:

- To repeat the first GPS campaign, occurred in 1995, in order to support the computation of velocities for the SIRGAS reference network stations;
- To collect GPS data for the WG III activities.

Hence the stations established during the first phase of the project were re-occupied. Additional stations were established in tide gauges, with the objective of supporting the integration of the classical altimetric systems into the new unified one, and others set up close to international borders in order to facilitate the link between the national vertical systems. North America, Central America and Caribbean participated in this campaign, establishing a geodetic network that covers the whole American continent from north to south. More than 180 stations were occupied during the campaign. The majority of collected data has already been sent to the data centers, at DGFI and IBGE. The corresponding stations are shown in Figure 4. Additional ten stations from the US CORS (Continuously Operating Reference Stations) network [http://www.ngs.noaa.gov/CORS/] may be considered to improve station distribution in USA.

The next activities include an independent campaign processing by DGFI and IBGE. The preliminary results are going to be presented at the IAG International Symposium on Vertical Reference Systems, to be held from February 20 to 23, 2001, in Cartagena, Colombia. (more information can be found at the event's homepage: http://www.igac.gov.co/veres.html or http://www.dgfi.badw.de/veres/veres.html).

SIRGAS PUBLICATIONS

All project publications are issued by IBGE, as the central bureau. They are published in two versions: Portuguese/Spanish and English. The following ones were published by now:

- **Newsletters**. They describe the project activities as long as they are being carried out.
  - ✓ #1: Sep. 1994
  - ✓ #2: Dec. 1994
  - ✓ #3: Dec. 1995
  - ✓ #4: Dec. 1996
  - ✓ #5: Feb. 1998

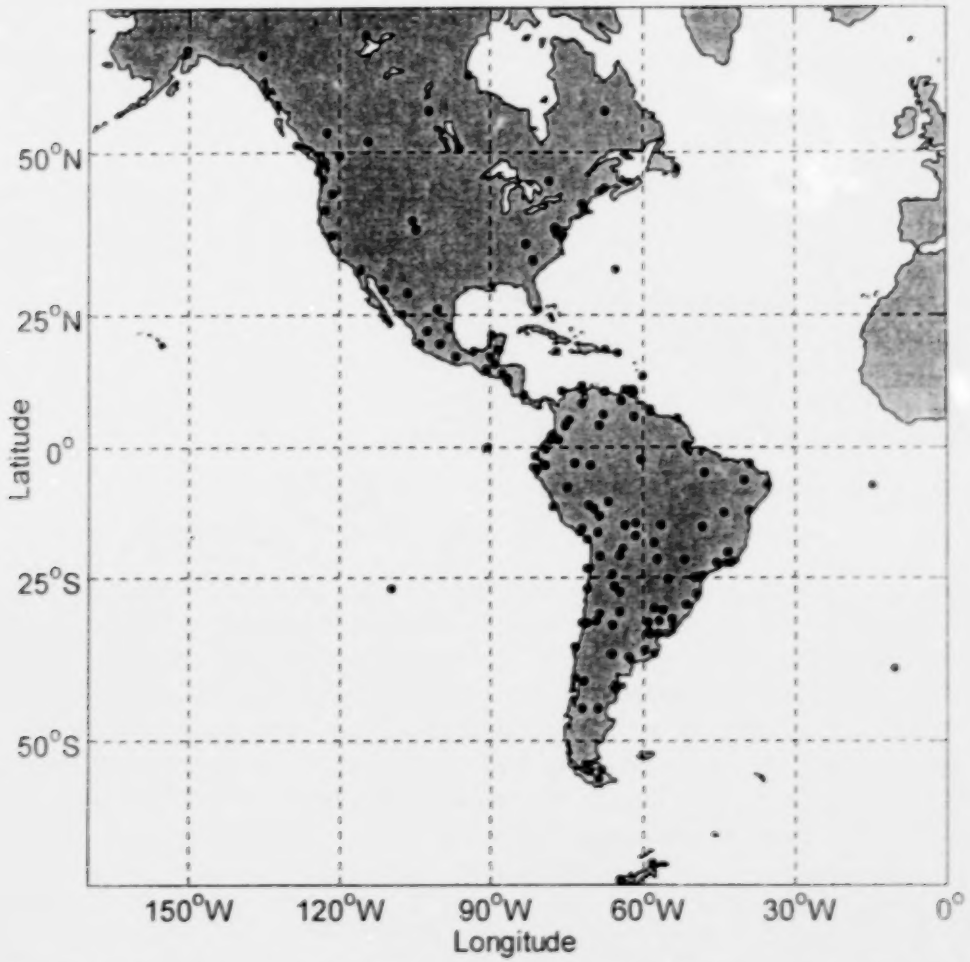

Figure 4: Stations occupied during the SIRGAS 2000 GPS campaign (total of 178 by November 2000). Additional ten stations from the US CORS network may be considered to improve station distribution in USA

- **Final Report, Working Groups I and II**. It contains a complete description of the project, details about the SIRGAS 95 GPS campaign processing carried out by DGFI and NIMA, including the official results, and reports from South-American countries with respect to the national geodetic networks integration into SIRGAS.

  ✓ Sep. 1997, distributed during the IAG Scientific Assembly, in Rio de Janeiro.

All publications are available for download at the SIRGAS homepage, located at the following address: http://www.ibge.gov.br/geografia/seminario/sirgas/principal.htm.

CONCLUSION

The SIRGAS project encompasses all activities necessary to establish a modern geodetic framework in the continent, compatible with the most accurate positioning techniques available nowadays. The adoption of a geocentric system based on ITRF guarantees that SIRGAS will always continue to be up-to-date, according to the georeferencing requirements of the new millennium.

ACKNOWLEDGEMENTS

The project has been extremely successful. This was only possible due to the high level of cooperation obtained from each participant, including the South American countries, the sponsoring organizations and the scientific consultants, representing more than 30 institutions from the Americas and Europe, all working towards the development of the South American continent. This cooperation was again observed during the SIRGAS 2000 GPS campaign, with the additional participation of several institutions from North America, Central America and Caribbean.